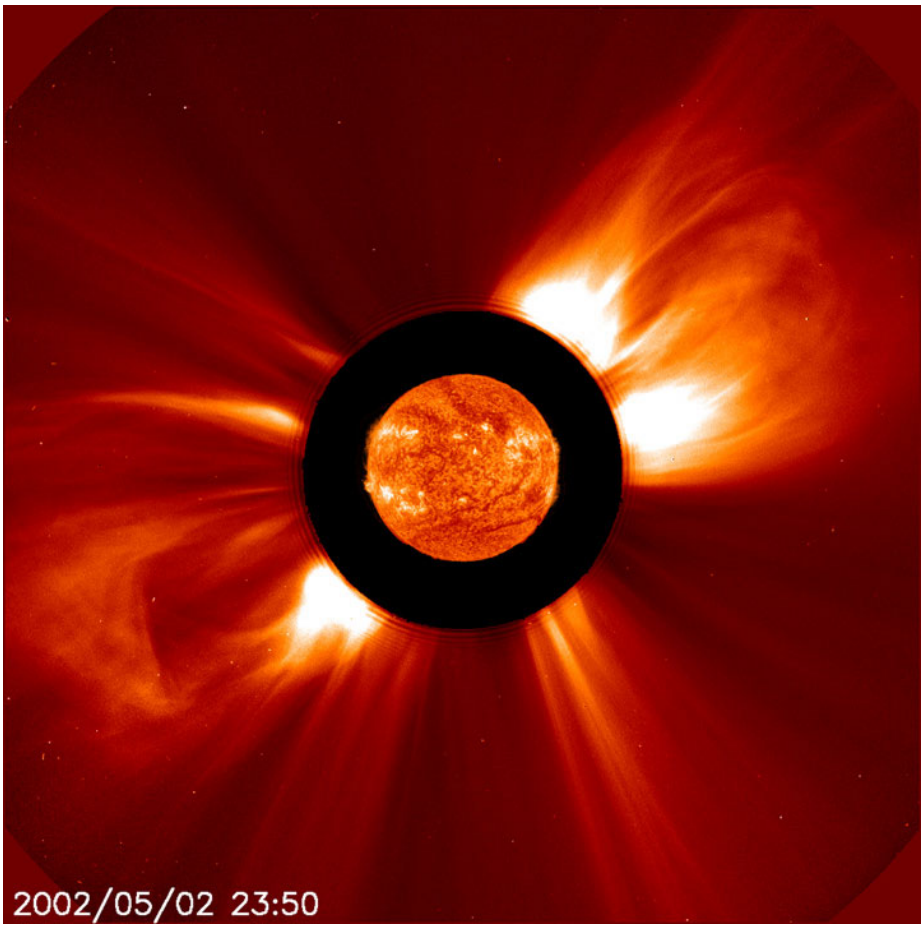
Classroom Activities

The Violent Sun

Double Trouble Solar Bubbles



On May 2, 2002, two enormous clouds of energetic particles blasted away from the solar surface in nearly simultaneous eruptions. Known as coronal mass ejections (CME's), they appear as large "bubbles" oriented at about 2 o'clock and 8 o'clock in this composite image from cameras onboard the Sun-staring SOHO spacecraft.
Source: http://antwrp.gsfc.nasa.gov/apod/ap020516.html

Subjects

Supercomputers, coronal mass ejections (CMEs), corona, solar prominences, magnetic fields, LASCO, SOHO

Background

Scientists believe that coronal mass ejections (CMEs) erupt from the Sun's outer corona as a huge bubble of plasma. The energy supply needed to produce the violent explosion of a CME is believed to come from the Sun's complicated magnetic fields that burst from its interior. Navy scientists are using supercomputers to seek the trigger of these ejections.

The larger and higher magnetic fields are believed to hold down the newer, smaller fields emerging from the surface, restraining the plasma and the magnetic fields trying to rise to the corona. Tremendous energy builds up and as heat is added to the bubble, it begins to accelerate, soon escaping the Sun's gravitational field.

A CME speeds across space at great velocities, carrying a 10 billion-ton bubble of plasma into the solar system. The energy in this bubble of plasma is comparable to the energy combined in 100 hurricanes.

As the CME plows through space, it creates a shock wave that accelerates particles to dangerously high speeds, bombarding planets, asteroids, and other objects with radiation and plasma. If the CME erupts on the side of the Sun facing the Earth, and our orbit intersects the path of the plasma cloud, the results can be both spectacular (auroras) and dangerous to some of our modern technologies.

When a CME dumps 1,500 gigawatts of electricity (double the electric generating power of the entire United States) into the atmosphere, big changes occur that can wreak havoc on satellites. As a society we have come to depend on satellites, electrical power, and radio communication–all of which are affected by these electric and magnetic forces. Since so much information is relayed by satellites–from ATM machines and broadcast signals to disaster warning systems–CMEs pose a technological hazard to our civilization.

Prior to viewing "Journeys through Earth and Space," The Violent Sun, students should be familiar with:

- General structure of the Sun
- Sunspots (and sunspot cycle) and prominences
- Magnetism and magnetic fields

Lesson Plan

Objectives:

Students will

> Recall, from the video, the mechanism for triggering coronal mass ejections.
> Describe an event in which an Earth-orbiting satellite was affected by solar activity.
> List some other effects at Earth of space weather.
> Visit Internet sites to gain information and understanding to learn why coronal mass ejections occur and the impact they have on satellites above the Earth's atmosphere.
> Model magnetic fields found on the Sun's surface.

Engage:

1. Activity 1: Space Weather's Impact on Earth
Students recall or research a recent event in which a satellite was affected by solar activity.

Although references are provided, students are encouraged to independently search the Internet or other references to locate a solar event that adversely affected an Earth-orbiting satellite.

References:

- Effects of Space Weather Events
  http://www.windows.ucar.edu/spaceweather/spweather_5.html
- Telstar 401
  http://www.cnn.com/TECH/9701/20/cosmic.rays/
- The Anik Panic
  http://www.windows.ucar.edu/spaceweather/anik.html

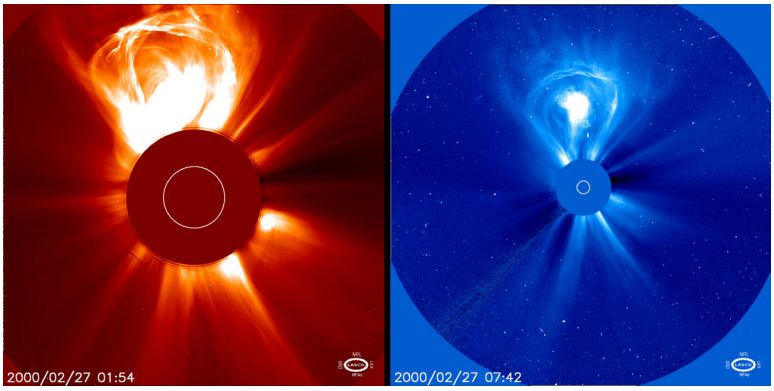
Questions to explore and discuss:

- Describe the circumstances of the event.
- When did it occur?
- What satellite was involved?
- What was the damage to the satellite?
- What was the economic impact?
- Identify ways in which scientists may protect satellites from damage from solar events.

The teacher may conduct a discussion to determine unique and common factors to the events found by the students. A chart may be helpful to compare and contrast the student responses.

2. Video Activities

Have students complete the Pre-viewing Activities.
Show the video "Journeys through Earth and Space," The Violent Sun. Students will complete the Video Viewing Questions. Discuss answers to the Viewing Questions.



"Lightbulb" CME. A coronal mass ejection on Feb. 27, 2000, taken by LASCO C2 and C3. A CME blasts into space 1 billion tons of particles traveling millions of miles an hour. This particular CME is "lightbulb-shaped."
Source: http://sohowww.nascom.nasa.gov/bestofsoho/PAGE3/

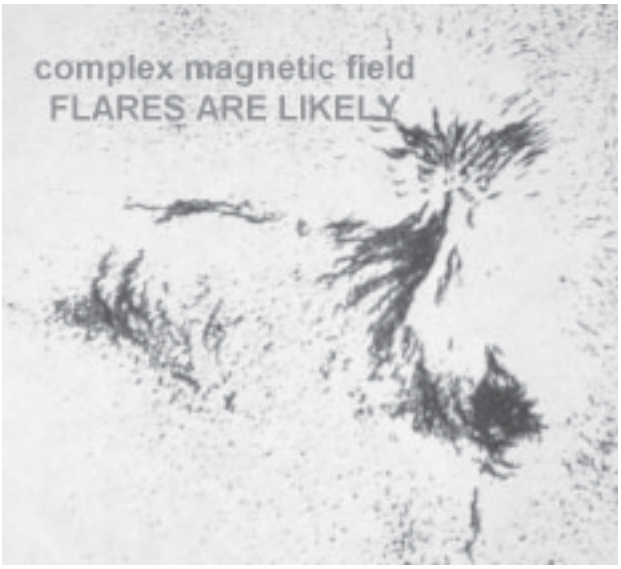
Students should visit the following Web sites and perform the activity or activities.

Explore:
Activity 2A
Coronal Mass Ejections: Satellites in Peril
http://edmall.gsfc.nasa.gov/inv99Project.Site/Pages/cme.abstract.html

Explain:
Activity 2B
Coronal Mass Ejections & Their Effect on Earth – A Student Activity
http://www-istp.gsfc.nasa.gov/istp/nicky/cme-activity.html

The following investigations are supplementary and will augment learning about the release of CMEs from the Sun.

Extend:
1. Supplementary Activity 1: Sunspot Twister



Students visit the following Web site and perform the investigation:
Sunspot Twister
http://www.thursdaysclassroom.com/12jun01/teach7.html

2. Supplementary Activity 2: Solar Rubber Bands

Students visit the following Web site and perform the investigation:

Solar Rubber Bands
http://www.thursdaysclassroom.com/12jun01/activity2.html

Refer to http://www.spacescience.com/headlines/y2000/ast05apr_1m.htm for information about solar magnetic fields and their measurement.

Evaluate:
Journal Write
Students should compose an essay that summarizes their learning about the Sun's effect on Earth's environment. Topics should include:

Sunspots	Aurorae
Solar Flares	Magnetic Fields
Coronal Mass Ejections	Magnetosphere

Activity Reading Level: Flesch-Kincaid: 8.5

National Standards (Science Content)
Grades 9-12

Science as Inquiry–Content Standard A:
Abilities Necessary to Do Scientific Inquiry

- Use technology and mathematics to improve investigations and communications.
- Formulate and revise explanations and models using logic and evidence.
- Recognize and analyze alternative explanations and models.

Physical Science–Content Standard B:
Motion and Forces

- Between any two charged particles, electric force is vastly greater than the gravitational force.
- Objects change their motion only when a net force is applied.

Science and Technology–Content Standard E:
Abilities of Technological Design

- Identify a problem or design an opportunity.}

Additional References

Solar Physics Homepage, NASA Marshall Space Flight Center
http://science.msfc.nasa.gov/ssl/pad/solar/the_key.htm

SOHO Homepage, NASA Goddard Space Flight Center
http://sohowww.nascom.nasa.gov/
A good source of lesson plans about the sun and solar physics.

Coronal Mass Ejections, Solar Flares, and the Sun-Earth Connection
http://hesperia.gsfc.nasa.gov/sftheory/cme.htm

Coronal Mass Ejections
http://science.msfc.nasa.gov/ssl/pad/solar/cmes.htm

The Sun-Earth Connection Education Forum
http://sunearth.gsfc.nasa.gov

It Takes a Telescope and a Microscope, INSIGHTS Magazine, April 2000
http://ct.gsfc.nasa.gov/insights/vol13/tele.htm

Credits

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The Violent Sun

Pre-viewing Activities

Question

What are some ways in which the Sun is harmful to humans and Earth?

Vocabulary to Know

Corona
Coronal Mass Ejection (CME)
Plasma
Prominence

Video Viewing Questions

1. The Sun is not only a life giver, but also a _____.

2. The most deadly solar storms are _____.

3. The corona is the Sun's _____.

4. Most CMEs start out as _____.

5. Prominences are arches of _____ that rise above the _____.

6. How do solar prominences compare to the atmosphere around them? _____
_____.

7. Scientists believe that _____ suspend prominences above the Sun's surface.

8. In simulating the escape mechanism of these eruptions, scientists crashed the computers. How does the PARAMESH software tackle this problem? _____
_____.

9. Two things scientists are hoping to learn from computer calculations are:
a. _____ and
b. _____.

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Educators' Answer Key

Pre-viewing Activities

Question

Some everyday examples include sunburn from prolonged exposure, sunlight making it difficult to see when driving, and parked cars being heated to temperatures that are dangerous to children and pets. An effective introduction to the video story might include mentioning that the Sun can also be dangerous to the satellites that broadcast television and other services to the world.

Video Viewing Questions

1. Destroyer
2. Coronal mass ejections
3. Outer atmosphere
4. Prominences
5. Gas, Sun's surface
6. Prominences are very cold and very dense.
7. Magnetic fields
8. PARAMESH targets a simulation's mesh or grid where things are changing.
9. Several hours' warning before a CME erupts, a very accurate characterization of the CME as it moves towards the Earth